Claims

[c1] A device to measure individual or grouped cell voltages of a fuel cell stack having conductive areas to monitor fuel cell stack performance to provide diagnostic data, said device comprising:
a meter connected to individual or grouped cell conductive areas to measure the voltage of said individual or grouped cells; and
a monitor coupled to said meter to report on the performance of the fuel cell stack,
such that the measurements of said individual or grouped cells are used to report on the performance of said fuel cell stack.

[c2] The device of Claim 1, wherein said meter further includes
a contact assembly associated with said individual or grouped cell conductive areas, wherein said contact assembly is electrically connected to said individual or grouped cell conductive areas; and
a multiplexor to switch between electrical connections of individual or grouped cells establishing an electrical signal path from an individual cell or group of cells; and,
an attenuator/amplifier to attenuate or amplify said electrical signal from said multiplexor; and,
a converter to convert the electrical signal from said attenuator/amplifier from an analog signal to a digital signal; and,
a microprocessor to read and interpret said digital signal,
wherein said microprocessor communicates the measurement value or any diagnostic data based on said measurement to said monitor.

[c3] The device of Claim 1, wherein said meter instructs said monitor to report on individual cells, grouped cells, or entire fuel cell stack performance.

[c4] The device of Claim 2, wherein said microprocessor determines the performance of individual cells or cell groups based on the present operating current of the fuel cell stack.

[c5] The device of Claim 2, wherein said microprocessor determines the

performance of individual cells or cell groups based on measurements of the time response of the voltage of said individual cells or cell groups during a transient response caused by a high rate of change of fuel cell stack current.

[c6] The device of Claim 2, wherein said microprocessor determines the performance of individual cells or cell groups based on measurements of the frequency response of the voltage of said individual cells or cell groups during a response caused by a periodic change of fuel cell stack current.

[c7] The device of Claim 2, wherein said microprocessor determines the performance of individual cells or cell groups based on voltage measurements of said individual cells or cell groups in addition to at least one other fuel cell system parameter.

[c8] The device of Claim 7, wherein said microprocessor determines the performance of individual cells or cell groups based on a logged history of voltage measurements of said individual cells or cell groups and other fuel cell system parameters.

[c9] The device of Claim 2, wherein said microprocessor instructs a current load in communication with said microprocessor, electrically connected to said fuel cell stack, to provide a current load to the fuel cell stack in order to measure the voltage of individual cells or cell groups at various fuel cell stack operating currents.

[c10] The device of Claim 9, wherein said current load is a battery charger coupled to said microprocessor.

[c11] The device of Claim 5, wherein said microprocessor instructs a current load, electrically connected to said fuel cell stack, to modulate the current of the fuel cell stack in order to measure the transient response of the voltage of individual cells or cell groups.

[c12] The device of Claim 6, wherein said microprocessor instructs a current load, electrically connected to said fuel cell stack, to modulate the current of the

fuel cell stack in order to measure the frequency response of the voltage of individual cells or cell groups.

[c13] The device of Claim 2, wherein said microprocessor measures the contact resistance between electrical contacts of said contact assembly and said conductive areas of said individual cells or cell groups, to determine the condition of an poor electrical connection and potential false voltage reading.

[c14] The device of Claim 1 further including:
one or more additional meters connected to said meter to allow the measurement of voltages of additional individual cells or grouped cells.

[c15] The device of Claim 1, wherein said meter provides electrical isolation between individual cells or grouped cells connected to and external electrical connections of said meter.

[c16] The device of Claim 2 wherein said meter further includes:
an electrical connection from said multiplexor output to allow connection of the multiplexor output signal to external measurement devices.

[c17] The device of Claim 1, wherein said meter further includes:
a voltage or current excitation source in electrical connection with said multiplexor and temperature sensing devices to provide for a method to allow compatibility with temperature sensing devices to allow multiple point temperature measurements.

[c18] The device of Claim 1, wherein said meter includes:
an alarm or an electrical connection for an external alarm device.

[c19] The device of Claim 1, wherein said monitor includes:
a personal computer running interface and monitoring software.

[c20] The device of Claim 1, wherein said monitor:
displays present, minimum, maximum, and average voltages of individual cells or grouped cells or of performance parameters based on these voltages.

[c21] The device of Claim 1, wherein said monitor:
provides a strip chart or graphical trend of voltages of individual cells or grouped cells or of performance parameters based on these voltages.

[c22] The device of Claim 1, wherein said monitor:
logs or stores a history of voltages of individual cells or grouped cells or of performance parameters based on these voltages.

[c23] The device of Claim 1, wherein said monitor:
displays impedance models based on voltages of individual cells or grouped.

[c24] The device of Claim 1, wherein said monitor:
provides automated sequencing and data collection of performance tests.

[c25] A device to measure individual or grouped cell voltages of a fuel cell stack having conductive areas to monitor fuel cell stack performance to adjust fuel cell system operating parameters to optimize fuel cell stack performance and to maintain safe operating conditions:
a meter connected to individual or grouped cell conductive areas to measure the voltage of said individual or grouped cells; and
a controller coupled to with or comprised in part of said meter to adjust fuel cell system operating parameters,
such that the measurements of said individual or grouped cells are used to adjust fuel cell system operating parameters to optimize fuel cell stack performance and to maintain safe operating conditions.

[c26]

The device of Claim 25, wherein said meter further includes:
a contact assembly associated with said individual or grouped cell conductive areas, wherein said contact assembly is electrically connected to said individual or grouped cell conductive areas; and
a multiplexor to switch between electrical connections of individual or grouped cells establishing an electrical signal path from an individual cell or group of cells; and,
an attenuator/amplifier to attenuate or amplify said electrical signal from

said multiplexor; and,
a converter to convert the electrical signal from said attenuator/amplifier from an analog signal to a digital signal; and,
a microprocessor to read and interpret said digital signal,
wherein said microprocessor communicates the measurement value or any evaluations based on said measurement to said controller.

[c27] The device of Claim 25, wherein said meter instructs said controller to adjust fuel cell system operating parameters to optimize fuel cell stack performance and to maintain safe operating conditions.

[c28] The device of Claim 25, wherein said meter instructs said controller to perform a fuel cell system shutdown procedure to avoid unsafe operating conditions or fuel cell stack damage.

[c29] The device of Claim 26, wherein said microprocessor determines the performance of individual cells or cell groups based on the present operating current of the fuel cell stack.

[c30] The device of Claim 26, wherein said microprocessor determines the performance of individual cells or cell groups based on measurements of the time response of the voltage of said individual cells or cell groups during a transient response caused by a high rate of change of fuel cell stack current.

[c31] The device of Claim 26, wherein said microprocessor determines the performance of individual cells or cell groups based on measurements of the frequency response of the voltage of said individual cells or cell groups during a response caused by a periodic change of fuel cell stack current.

[c32] The device of Claim 26, wherein said microprocessor determines the performance of individual cells or cell groups based on voltage measurements of said individual cells or cell groups in addition to at least one other fuel cell system parameter.

[c33] The device of Claim 32, wherein said microprocessor determines the

performance of individual cells or cell groups based on a logged history of voltage measurements of said individual cells or cell groups and other fuel cell system parameters.

[c34] The device of Claim 26, wherein said microprocessor instructs a current load in communication with said microprocessor, electrically connected to said fuel cell stack, to provide a current load to the fuel cell stack in order to measure the voltage of individual cells or cell groups at various fuel cell stack operating currents.

[c35] The device of Claim 34, wherein said current load is a battery charger in communication with said microprocessor.

[c36] The device of Claim 30, wherein said microprocessor instructs a current load, electrically connected to said fuel cell stack, to modulate the current of the fuel cell stack in order to measure the transient response of the voltage of individual cells or cell groups.

[c37] The device of Claim 31, wherein said microprocessor instructs a current load, electrically connected to said fuel cell stack, to modulate the current of the fuel cell stack in order to measure the frequency response of the voltage of individual cells or cell groups.

[c38] The device of Claim 26, wherein said microprocessor measures the contact resistance between electrical contacts, of said contact assembly and said conductive areas of said individual cells or cell groups, to determine the condition of an poor electrical connection and potential false voltage reading.

[c39] The device of Claim 25 further including:
one or more additional meters to allow the measurement of voltages of additional individual cells or grouped cells connected to said meter.

[c40] The device of Claim 25, wherein said meter provides electrical isolation between individual cells or grouped cells connected thereto and external

electrical connections of said meter.

[c41] The device of Claim 26, wherein said meter further includes an electrical connection from said multiplexor output to allow connection of the multiplexor output signal to external measurement devices.

[c42] The device of Claim 25, wherein said meter further includes a voltage or current excitation source in electrical connection with said multiplexor to provide for a method to allow compatibility with temperature sensing devices to allow multiple point temperature measurements.

[c43] The device of Claim 25, wherein said meter further includes an alarm or an electrical connection for an external alarm device.

[c44] The device of Claim 25, wherein said controller controls at least one control parameter of the fuel cell system.

[c45] The device of Claim 44, wherein said controller modulates the flow of at least one of the reactant gases entering the fuel cell stack.

[c46] The device of Claim 44, wherein said controller modulates the humidification of at least one of the reactant gases entering the fuel cell stack.

[c47] The device of Claim 44, wherein said controller modulates the temperature of at least one of the reactant gases entering the fuel cell stack.

[c48] The device of Claim 44, wherein said controller modulates the temperature of the fuel cell stack.

[c49] The device of Claim 44, further including reactant gases and wherein said controller modulates or limits the output load current of the fuel cell stack.

[c50] The device of Claim 44, wherein said controller modulates control parameters according to individual or grouped cell performance parameters.

[c51] The device of Claim 25, further including switches wherein said controller instructs switches electrically connected to individual cells or cell groups to

isolate said individual cells or cell groups and provide a current bypass.

[c52] The device of Claim 2, wherein said contact assembly a plurality of electrical connections positioned at a plurality of points around the perimeter of said individual or grouped cells.

[c53] The device of Claim 52, wherein said meter interprets differences in voltages, measured at a plurality of points around the perimeter of said individual or grouped cells, to provide a determination of a disproportionate current density distribution across the the plane of individual cells.

[c54] The device of Claim 1, further includes batteries or supercapacitors coupled to said cells.